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NANO CATALYSTS FOR BIODIESEL PRODUCTION- A REVIEW

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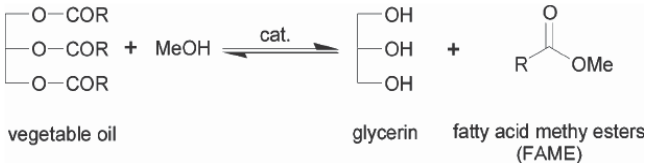
Abstract - The world we are living in today has a lot of demands, one of them is Energy. Global energy usage is on the peak due to rapid industrialization. The constant depletion of sources of fossil fuels and long term increase in average atmospheric temperature has given rise to energy shortage and it hampering environment drastically. Renewable energy is an alternative source that will provide us clean, sustainable and efficient power. Biodiesel is also one of the promising resources with great potential. Biodiesel is nothing but a diesel produced from organic sources which contain free fatty acids through the trans-esterification process that uses alcohol and catalyst. There are N number of researches are done on biodiesel for improving efficiency of biodiesel production as well as to reduce its production complexity and cost. There are varieties of catalyst used to get desired biodiesel yield. Heterogeneous catalyst has shown desired potential to reduce cost as well as complexities. This review is focused on recent researches carried out on nanocatalyst used to produce biodiesel.

***Key Words*:** Biodiesel production, Nano catalysts

1. INTRODUCTION

Now a day's demand of energy and fuel is on the peak; with demand its prices are reaching to the sky. Using an alternative source is viable and efficient way to reduce the stress on conventional fuels like coal but what about vehicles and transport systems? Due to vast requirement of transport system fuel sources depleting rapidly. This situation leads to find an alternative fuel source. Biodiesel is one of the promising and efficient sources of fuel.

Biodiesel is an organic fuel which is obtained from vegetable oils or animal fats. The raw product used to obtain such fuels is known as feed-stocks. There are variety of oils are available such as sunflower, cotton seeds, karanja, jatropha, soybean etc. Some experiments also showed that biofuel can also be obtained from animal fats like goat, chicken etc. The process of obtaining biodiesel from feedstock is known as "transesterification".



In this process the crude oil which is obtained from these feed stocks reacted with "Catalysts" and forms FAME i.e. Fatty Acid Methyl Esters. This FAME has properties similar to traditional diesel fuel.

The catalyst which used for above mentioned esterification process has several types like: -

1. Homogenous catalysts:-

This is the first and conventional method to get biodiesel. There are two types of homogenous catalyst one is acidic and other is alkaline. The selection between acidic or basic primarily depends on free fatty acid content of oil; the FFA content depends on origin of oil seeds, cultivation method, processing parameters, and storage facility. Generally, base or alkaline catalyst is used to get FFA from non edible oil. In the presence of alkaline catalyst, the FFA present in the feedstock produces soap, which decrease its yield and also cause catalyst loss thus separation of oil from catalyst becomes complex

2. Heterogeneous catalysts:-

The biodiesel yield earned by homogenous catalyst has lot of disadvantages such as high energy consumption, soap formation in high FFA oil, difficulty in catalytic separation, large amount of waste water production etc. To overcome from these problems heterogeneous catalyst comes in picture.

3. Enzymatic catalysts:-

Another reliable type of catalyst is enzymatic catalyst. Enzymatic catalyst can also be used with high FFA feedstock. This can convert oil without generation of bi-products. The operation can be done under mild reaction conditions and can convert more quantity of oil into biodiesel.

In this paper, we reviewed on how different catalyst effects on biodiesel production yield also which catalysts are suitable for biodiesel production effectively.

2. Literature Review

MoinaAthara, SadafZaidib et.al (1) stated that, from literature it is revealed that the virgin oil gives higher yield that is around 97% compared to waste frying oil i.e. around 92%. Some of the examples of alkaline catalysts are KOH, CH3ONa, NaOH etc. On the other hand, if we focus on acidic catalyst they are less sensitive to the FFA in the oil due to their ability to catalyze both FFA and triglycerides. The biodiesel yield gained by acid catalyst is around 90%. But conversion of biodiesel using acidic catalyst is quiet slow process in order to get higher efficiency output.

The biodiesel yield earned by homogenous catalyst has lot of disadvantages such as high energy consumption, soap formation in high FFA oil, difficulty in catalytic separation, large amount of waste water production etc.

To overcome from these problems heterogeneous catalyst comes in picture. Unwanted sopification can be avoided and also heterogeneous catalysts are used several times. It also leads to cheaper production cost. Studies show that the yield gained by heterogeneous catalyst experimented on karanja oil is around 99.86%.

Another reliable type of catalyst is enzymatic catalyst. Enzymatic catalyst can also be used with high FFA feedstock. This can convert oil without generation of bi-products. The operation can be done under mild reaction conditions and can convert more quantity of oil into biodiesel. But these catalysts are not much used because of some issues like high cost and longer reaction time. Some of the examples are lipozyme TL, liozyme RMIM, ZIF-67etc.

The higher cost of biodiesel is a big obstacle for its wide use as a strong and reliable alternative fuel to diesel. The alkaline catalyst is cheapest option to gain biodiesel from high quality edible oil. Production of biodiesel from alkaline catalyst involves less number of equipments so comparatively it is investment. Apart from this, heterogeneous type of catalyst is also a convenient option as it is reusable.

J B Galcharet.al (2) comments that, the transesterification reaction of oil and alcohol with a homogeneous catalyst is the general method for the preparation of biodiesel. However, the homogeneous catalysts have many shortcomings, such as requiring large amounts of water, difficulties in product isolation, and environmental pollution caused by the liquid wastes.

Production of biodiesel with conventional transeseterification takes almost 24 hours, whereas using heterogeneous nano catalyst for transesterification in only one hour so it is time saving process. Heterogeneous nano catalyst is reusable for process and separation are easy and the amount of yield is increase compare to conventional method.

Nano catalysts used for above study are as follows: CaO-Al2O3, KF/CaO-Fe3O4, iron nano particles as catalyst, Nano MgO as Catalyst, CuO:Mg Heterogeneous Nano catalyst.

Nagesh S. B.a, N. R. Banapurmathb, Chandrashekhar T. Kc. &Sanjeevkumar V. Khandaldet.al (4)stated that, CaO is used as nano catalyst which is heterogeneous catalyst. It has purity around 99.9%. Different analysis methods were performed on catalyst in order to determine structural properties as well as surface properties of catalyst.

The yield obtained by using CaO catalyst is 93.72% which is produced at optimized condition.

Linus OkoroaGubihamaJoelbet.al (5),comments that Characteristics such as high basicity, regeneration and reusability in addition to proper preparation and environmental safety make nanocatalysts suitable for biodiesel production. Various investigations covered in this review lead to the conclusion that nanocatalyst for biofuel production can enhance biodiesel production by far greater percentage compared to homogeneous catalyst. The various types of nanocatalysts used in recent times are metal oxides (CuO), metal oxide supported by metal oxide (KF-ZnO- Fe3O4) and metal supported on metal oxides (Au-ZnO).

JabbarGardyaaa, Mohammad Rehanbbb, Ali Hassanpourac,cXiaojunLaiadc, Abdul-SattarNizamibed et.al (3), This paper aims to examine the influence of various catalysts on biodiesel production, especially from non-food feed stocks with an ambition to optimize the catalytic biodiesel production. A catalyst changes the rate of esterification and transesterification reactions without being consumed. Lower activation energy is

normally obtained for catalytic esterification and transesterification reactions compared to non-catalytic processes.

I. M. RizwanulFattaha, H. C. Ong1b, T. M. I. Mahliac, M. Mofijurc, A. S. Silitongad, S. M. Ashrafur Rahmane and ArslanAhmadf et.al (6), this paper is throwing light on the time required for obtaining a yield. It states that, the time required to get desired output with the help of heterogeneous catalyst is more. In order to minimize time to achieve biodiesel yield base homogenous catalysts are the best suited. It possesses quick reaction time with superior yield quality.

Avinash P. Inglea ,Anuj K. Chandelb ,Rafael Philippinic, Sabrina EvelinMartinianod and Silvio Silvério da Silvae et.al (7), the paper states that, nano catalyst has some distinctive properties like selective reactivity, high activation energy and controlled rate of reaction, easy and quick recovery rate and ability to recycle as well. Biodiesel can be produced by four major methods namely, (i) base-catalyzed processes,(ii) acid-catalyzed processes,(iii) enzyme-catalyzed processes, and(iv) Use of supercritical conditions. Etc.
Homogenous base catalyzed nano catalyst is cheapest and widely used method for production of biodiesel. Various base catalyst such as sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium methoxide (NaOCH3) and sodium ethoxide (NaOCH2CH3) are commonly used as the catalysts. But there are various drawbacks are associated with base catalyst like separation difficulty, sopinification etc. likewise there are few drawbacks are also associated with acid catalysts. So in order to eliminate the limitations occurred by this two catalyst enzymatic catalysts are introduced as reliable source.

Ivana B. Banković–Ilića, Marija R. Miladinovićb, Olivera S. Stamenkovićc, Vlada B. Veljkovićd et.al (8), This article highlights the role of nano catalyst in terms of aspects like environmental, social, technological and scientific point of view. Nano catalyst has some significant features like activity, selectivity, durability, recoverability etc.
The paper also summarise the current trend and reliable potential of using nanoCaO based catalyst as heterogeneous catalyst in order to biodiesel production. It also reveals that different forms of nanoCaO catalyst (neat, doped, loaded) are used in biodiesel synthesis. The effectiveness of this catalyst is depend upon on their basicity, specific surface area and activity even at room temperature, as well as the possibility of regeneration and reusability, the proper preparation, activation and regeneration methods should be applied in order to obtain an adequately active and stable form of nanoCaO catalysts.

I.M. Atadashia, M.K. Arouab, A.R. Abdul Azizc, N.M.N. Sulaimandet.al (9),
This paper gives some recommendations about on catalytic properties: -

1. Using feed stocks whose FFA values are more is an economical option for producing biodiesel, rather than producing biodiesel from crude oil with the help of alkaline catalysts.
2. From studies, it can be seen that acid catalysed transesterification reaction requires more alcohol to oil molar ratio.
3. The biodiesel produced from low quality feed stocks with the help of heterogeneous catalyst is a less complex process which even gives high yield value.
4. Tremendous effort should be made to exploit ways of improving the kinetic rate of CaO catalysts, since its catalytic activity is high, its catalyst life time is long and it operates under only mild reaction conditions.
5. Development of enzymes catalyst as a more environmentally benign process is necessary due to the prevailing environmental needs. Besides the process is potentially sound providing high quality biodiesel fuel that can compete favorably with petro diesel fuel.

FaeghehMoazenia, Yen-Chih Chen GaosenZhangb et.al (10), This paper is stating the advantages of enzymatic catalysts over other catalysts. From experiments it is clear that enzymatic catalysts are much more environmental friendly. For transesterification it doesn't require any pre treatment. The operational conditions can be varying to gain desirable yield.

Abhijeet Patil, Saroj S. Baral, Prashant Dhanke, Vivek Kore et.al (11), In this paper, TiO2-Cu2O nano catalysts are used to obtain biodiesel from thumba oil by using hydrodynamic cavitation method. The authors concluded that, almost 65% of triglycerides were converted from thumba oil. The reaction of thumba oil is depend upon mass transfer resistance and inlet pressure. An obtained optimum

parameter is useful to carry out this operation commercially on large scale for the industrial sector.

Rose Fadzilah Abdullah, Umer Rashid , Mohd Lokman Ibrahim , Balkis Hazmi , Fahad A. Alharthi , Imededdine Arbi Nehdi et.al(12), In this Paper author stated that, an efficient bifunctional impregnated with K2CO3 and Cu(NO3)2 on porous HTC activated carbon support based nanocatalyst was successfully prepared by the hydrothermal technique. Nanocatalyst produced biodiesel yield up to 95.36%.

Vijaya Kumar Booramurthya, Ramesh Kasimanib, Deepalakshmi Subramanianc, Sivakumar Pandiand et.al(13), Biodiesel is produced from tannery waste by transesterification reaction in the presence of Cs2O loaded onto a nano-magnetic core. The catalyst was prepared by co-precipitation followed by thermal oxidation method. In this study biodiesel was derived from fat extracted from tannery waste. It was catalysed by a reusable nano-catalyst (Fe3O4/Cs2O). The catalyst was prepared through co-precipitation followed by thermal oxidation method and characterized. The optimum reaction conditions were identified to get a maximum yield of 97.1 wt%.

N.A.F.A. Zik , S. Sulaiman , P. Jamal et.al(14),
In this study, biodiesel was synthesized from a reaction of waste cooking oil (WCO) and methanol in the presence of catalyst which was derived from chicken bone and coconut residue in a packed bed reactor. The maximum yield of 98.40% was obtained at optimum temperature, methanol to oil and catalyst loading of 65 degree C, 6:1 and 0.5 wt%, respectively.

3. CONCLUSIONS

Due to vast need of energy sources, increased demand of fuel and rapidly depleting traditional fuel sources; finding an alternative fuel source is became prior need. In order to meet this need, biodiesel is rising as promising source of fuel which has efficiency nearly equal to traditional fuel sources. Biodiesel is obtained from feed stocks with the help of catalysts. In this paper, apart from using traditional catalysts we are focused on nano catalysts which have various benefits over traditional homogeneous catalysts.

Characteristics such as high basicity, regeneration and reusability in addition to proper preparation and environmental safety make nanocatalysts suitable for biodiesel production. Various investigations covered in this review lead to the conclusion that nanocatalyst for biofuel production can enhance biodiesel production by far greater percentage compared to homogeneous catalyst.
It is to be recommended to future scientists who will put their efforts in field of biodiesel that instead of focusing on traditional catalysts it is better and beneficial to work on nano catalysts which has lesser impact on environment.

REFERENCES

[1] 1 Moina Athara, Sadaf Zaidib et.al (1) A review of the feedstocks, catalysts, and intensification techniques for sustainable biodiesel production.
[2] J B Galchar et.al (2) Production of biodiesel using Nano Catalysts, Review study
[3] Nagesh S. B. , N. R. Banapurmath, Chandrashekhar T. K. & Sanjeevkumar V.Khandalet.al (3) Biodiesel production from goat fat using calcium oxide nanocatalyst and its combination with diesel fuel to improve fuel properties.
[4] Linus Okoro Gubihama Joelet.al (4) Advanced Nanocatalysts for Biodiesel Production.
[5] Jabbar Gardya, Mohammad Rehanb,*, Ali Hassanpoura,*, Xiaojun Laia, Abdul-Sattar Nizamibet.al (5) Advances in nano-catalysts based biodiesel production from non-food feedstocks.
[6] I. M. Rizwanul Fattah1*, H. C. Ong1, T. M. I. Mahlia1, M. Mofijur, A. S. Silitonga, S. M. Ashrafur Rahman and Arslan Ahmad et.al (6) State of the Art of Catalysts for Biodiesel Production
[7] Avinash P. Ingle *,Anuj K. Chandel *,Rafael Philippini,Sabrina Evelin Martiniano andSilvio Silvério da Silvaet.al (7)Advances in Nanocatalysts Mediated Biodiesel Production: A Critical Appraisal
[8] Ivana B. Banković–Ilić, Marija R. Miladinović, Olivera S. Stamenković, Vlada B. Veljkovićet.al (8)Application of nano CaO–based catalysts in biodiesel synthesis
[9] Faegheh Moazeni[a], Yen-Chih Chen Gaosen Zhang[b] et.al (9), Advamtages and applications of enzymatic catalysts.
[10] I.M. Atadashi[a], M.K. Aroua[b], A.R. Abdul Aziz[c], N.M.N. Sulaiman[d] et.al (10), Review on various catalysts for biodiesel production.
[11] Abhijeet Patil[a], Saroj S. Baral[b], Prashant Dhanke[c], Vivek Kore[d] et. Al (11) Biodiesel production using prepared novel surface functionalised TiO2nano-catalyst in hydrodynamic cavitation reactor.
[12] Rose Fadzilah Abdullah[a], Umer Rashid[b] , Mohd Lokman Ibrahim[c] , Balkis Hazmi[d] , Fahad A. Alharthie , Imededdine Arbi Nehdi[f] et.al(12), Bifunctional nano-catalyst produced from palm kernel shell via hydrothermal-assisted carbonization for biodiesel production from waste cooking oil.
[13] Vijaya Kumar Booramurthya[a], Ramesh Kasimanib[b], Deepalakshmi Subramanian[c],

Sivakumar Pandiand[d], et.al(13), Production of biodiesel from tannery waste using a stable and recyclable Nano-catalyst: An optimization and kinetic study.

N.A.F.A. Zik[a] , S. Sulaiman[b] , P. Jamal[c] et.al(14), Biodiesel production from waste cooking oil using calcium oxide/Nano crystal cellulose/polyvinyl alcohol catalyst in a packed bed reactor.